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The Patent Office

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1. Your reference

P1135.GBA

2. Patent application number

0312567.1

(The Patent Office will fill in this part) 0 2 JUN 2003

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Newlands Technology Limited
Unit 3F Newlands Science Park
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HULL
HU6 7TQ

Patents ADP number *(if you know it)*

7857451002

If the applicant is a corporate body, give the country/state of its incorporation

United Kingdom

4. Title of the invention

AUDIO SYSTEM

5. Name of your agent *(if you have one)*

LOVEN & CO

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Quantum House
30 Tentercroft Street
LINCOLN
LN5 7DB

Patents ADP number *(if you know it)*

4467460003 ✓

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
(a) any applicant named in part 3 is not an inventor, or
(b) there is an inventor who is not named as an applicant, or
(c) any named applicant is a corporate body
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YES

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form 0

Description 10

Claim(s) 2

Abstract 0

Drawing(s) 3

10. If you are also filing any of the following, state how many against each item.

Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*

Request for preliminary examination and search *(Patents Form 9/77)*

Request for substantive examination *(Patents Form 10/77)*

Any other documents *(please specify)*

11. I/We request the grant of a patent on the basis of this application.

Signature Date 2 June 2003

12. Name and daytime telephone number of person to contact in the United Kingdom K J Loven (01522 801111)

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Notes

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AUDIO SYSTEM

Field of the Invention

This invention relates to an audio system. In one aspect, the invention relates to the conversion of an otherwise non-responsive rigid or flexible panel by the addition of high-force, wide-band acoustic actuators to create a smart surface that can emit and/or receive acoustic signals for the purpose of providing discreet audio or noise masking, or for sensing attack for security purposes. The audio system of this invention can be described as providing a single smart surface with its associated acoustic locus properties or an enclosed volume when a multiplicity of such panels is activated.

The volume to be influenced can be either a singular or multiple arrangements of smart surfaces, fixed or moving.

Background to the Invention

Flat panel loudspeakers are well-known, and typically consist of a rigid panel of laminated plastics, card or wood with an acoustic transducer attached to one face of the panel. Typical transducers are moving coil electromagnetic devices or piezoelectric devices.

Similarly traditional cone based directional speakers are well known for reproducing audio signals or masking signals to apparently reduce the effect of ambient noise.

Magnetostrictive devices are also known, for example of the type described and claimed in our co-pending International Patent Application PCT/GB02/01111. These devices can be used particularly when larger panels require to be activated to sound. The effect of sounding a large panel by means of a magnetostrictive actuator is to distribute the sound waves through the panel, as has been described in our co-pending application, as a distributed planar signal.

In a permanent or temporary building, it is known that there are multiple audio and security systems installed for many different purposes; these include audio reproduction, public announcement, supplementary emergency announcement, multi-media, and presentation amplification. Some installations also include active sound masking systems or passive sound insulation and privacy screening panels or active audio systems. Additionally

anti intruder, counter espionage or vandalism detection devices are frequently fitted particularly at low or easily accessible windows.

Audio reproduction is traditionally achieved using multiple cone speakers or flat panels.

Multi media is normally achieved by installing a dedicated cone speaker system.

Public announcement is traditionally achieved using multiple cone speakers or flat panels sometimes using the audio reproduction system.

Emergency announcement is traditionally achieved using multiple cone speakers or flat panels sometimes using the audio reproduction system.

Active sound masking is frequently achieved by accurately positioning a cone speaker above a personal area, or in the top corners of a room focussing down into the centre of the room where people normally congregate for example around a table. Flat speakers can be used for this purpose also. In most cases the installation is dedicated to this purpose.

Active privacy screening is normally achieved using multiple cone speakers or flat panels often dedicated to this purpose.

Passive sound insulation is commonly used in buildings to reduce the transmission of sound from one room or area to another.

Perimeters anti intruder devices are usually positioned on windows and doors and detect movement or vibration if disturbed.

Anti vandalism systems normally include video cameras, infrared lighting and intruder devices designed to detect movement.

Counter espionage issues are significant where relevant and would be the subject of additional passive security systems, i.e. window shutters or screens.

In some countries, Sweden for example, CCTV monitoring of individuals is not permitted unless it is known that the individuals are committing an offence or breaking the law.

As can be seen in many buildings the fragmentation of the systems design often results in a multiplicity of audio and screening systems, cameras, and detection devices often resulting in excessive costs and wasted resources.

New legislation relating to noise and its control in building standards in the US (HIPPA privacy standard) and in Europe introduce demands that combine some or all of the various functionality described above into one installation classification, offering an opportunity to create a new approach to satisfy the varying needs of architects and specifiers and construction contracting companies.

Summary of the invention

This invention relates to a system solution in which the panels that make up a building or vehicle are activated by either single or multiple types of sounders either by direct stimulation or in response to a sensing system, creating a single integrated system (smart surfaces) to achieve any number of levels of functionality, but not necessarily be limited to all, described above.

According to the invention, there is provided an audio system, for example for use in enclosed spaces, comprising an audio frequency actuator coupled to a panel, for example within or defining said enclosed space, so as to cause the panel to radiate sound when an audio signal is supplied to the actuator by a controller, and an acoustic sensor coupled to said panel or to an adjacent panel so as to sense acoustic vibrations in said panel, the sensor being connected to the controller, whereby the controller is arranged to change the audio signal supplied to the actuator according to the vibrations sensed by the sensor.

Another aspect of the invention provides an audio system, comprising an audio frequency actuator coupled to a panel so as to cause the panel to radiate sound when an audio signal is supplied to the actuator by a controller, and an acoustic sensor coupled to said panel or to an adjacent panel so as to sense acoustic vibrations in said panel, the sensor being connected to the controller, whereby the controller is arranged to detect predetermined characteristics of the sensed acoustic vibrations and to output an alerting signal in response thereto. This output may be acoustic, or may trigger a remote device, for example a CCTV camera or a remote alarm.

The audio frequency actuator can be integrated into the panel's construction, either internally or externally, or it could be retrospectively fitted to an existing panel.

Preferably this will include audio reproduction, public announcement, supplementary emergency announcement, multi-media, and presentation amplification. The invention may also address internal noise management, personal privacy screens, room privacy screens, external noise control, as well as possibly external counter espionage security and intruder and vandalism detection sensing.

The audio output that is seen when an actuator is coupled to a rigid panel transmits audio to both sides of the panel. The effect is approximately equal on both sides. This can be adjusted by the use of acoustic insulation whereby one side of the panel is acoustically insulated from the other by means of a soft infill material such as foam, rubber silicone or similar or a baffle or reflective materials to ensure the signal is predominantly in one direction. In some instances however the use of a two way communication is of value, for example on train windows where the audio within the carriage and on the platform would be a benefit. Similarly when a sensing system is incorporated this may be sensing on one side and acting on the other side of a panel (for example in a room in a hotel to reduce the effect of noise between rooms. Similarly in a double glazed unit the actuator may be on the inner of the front pane and sensing movement or pressure on the outer pane of glass.

As a system solution it is anticipated that smart surfaces will have advantages in many areas of both domestic and commercial buildings, transportation of any type, and temporary structures. including more cost effective sound installations, discreet and easier to design with opportunities, be more cost efficient, more reliable, addressable and future proofed to cater for new emerging higher demand building and accommodation standards.

According to another aspect of the invention, there is provided an acoustic device possibly but not limited to a magnetostrictive actuator acoustically coupled to a panel providing multiple functionality including some but not necessarily all and not limited to, the reproduction of music for entertainment purposes external public announcements, local public announcements, external supplementary emergency announcements multi-media reproduction and presentation amplification active sound masking of extraneous noise from the other side of the panel privacy screening and room privacy within the locus of

the panel or localised privacy screening panels within. Additionally anti intruder, counter espionage or vandalism detection devices may be included as a function of the system's ability to monitor the condition of the panel.

The actuator also may be able to intelligently sense activity on its outer face, either by reacting to sound pressure or physical pressure (wind noise, physical vandalism, or attack) or by recognising the effect of a tool or pen if scratched or written on.

A counter espionage aspect of the system is described and claimed in our co-pending International Patent Application PCT/GB02/01111.

Detection of external pressure, sound pressure or physical pressure will preferably be via a sensor integrated into the actuator or via a remote sensor. This sensor can either be integrated into the magnetostrictive actuator as a secondary function of the Terfenol-D material or similar or a piezo-electric (or ceramic) device in the line of excitation, above or below the active core. It may measure actual force or it may measure the reaction force. The function of this sensor is either to sense that actual output signal or to sense in order to instruct the active device.

In a particular type of graffiti a hardened tool or similar is used to damage the surface of the glass by scratching. This has a severe visual effect on the glass and is commonly referred to as Dutch Graffiti. Another form of graffiti is with marker pens and aerosol spray paint. In each case a different acoustic signal will be detectable in the glass or surface being sensed. In the case of the hardened tool, a distinct signature in the region of 250Hz to 12KHz can be recognised and a signal sent to the controller.

In the case of anti graffiti sensing and external ambient noise sensing, this can be determined in a number of ways. Either the encoder interface box will be set up to look for one or more of the types of signals it expects, for example marker pen or hardened tool, or it could alternatively be set to look for the trend associated with an arising external noise such as airplane or traffic noise. It can be understood that any number of presets or learning algorithms could be used to seek and mask or screen or issue an anti-phase signal to compensate or reduce the effect of the sensed noise. This could include noise from outside say a building site, noise from an adjoining room or space, noise from a specific signal such as a tool or an attack or vandalism as described or simply to create a

local ambient noise screen that will mask conversation or discussion in one part of a room.

It will be understood that, while the surface or panel to be sounded might conveniently have a generally rectangular shape, for example when used as a window, the invention is not limited to the use of smart surfaces having any particular shape or purpose.

The smart surface could be a wall, or a door, or a ceiling or a floor. A number of smart surfaces could be attached together to create a room. The room could be a single module as in a temporary building or self contained cabin, or it could be part of a multiplicity of rooms as in a building. The rooms could be within larger rooms. The rooms may be static and anchored to the ground, or mobile and part of a transport system. The rooms may be subdivided with different functionality provided by alternate smart surfaces that use the same invention to provide for the acoustic environment as described.

The construction of the smart surface can vary, the common features being rigidity (at least in one axis) and size, including, glass, plastic, metal, MDF, sheet GRC, GRP, plasterboard, dry-wall, wood panelling or any other material used in the traditional building and transport industry.

The smart surface can be of composite construction using different types of material with cores and additional functionality skins, for example insulation board for temporary building construction, featuring structural integrity outer skins, solar reflecting sheets, foam cores structural honeycomb cores, aerospace aluminium honeycomb cores corrugated cores and extruded polycarbonate or similar structural sheets, and fire insulation membranes as integral parts of its makeup. The mass of the panel can be low (small window panels) to massive 400+Kg plate glass or single skin ceiling sheets suspended or adhered to a suitable support structure.

The actuator is preferably a giant magnetostrictive material (GMM) actuator, for example of the type described and claimed in our co-pending International Patent Application PCT/GB02/01111 or a scaled up version of the same. Preferably, the actuator is bonded discreetly within, or onto the panel or retrospectively fitted, for example by adhesive or by physical retention system of screws and mounting brackets.

Another application for the acoustic device of the invention is in the masking or perceived reduction of ambient noise. By combining with the device a sensor integrated into it or remotely mounted a distance from it or an integrated or remote microphone or the type that focuses some distance from its physical location and noise reduction or screening controller which generates an anti-phase masking or screening signal such as a white or pink noise signal corresponding to the noise received by the microphone or sensor, the device can be employed to reduce perceived noise in a room, noise coming into a room, or just affect noise in a part of a room. The noise reduction may be configured to have a broad-spectrum effect or to reduce the amplitude of selected frequency bands. By configuring the layout for example, it can be arranged to activate locally when required, either triggered by ambient noise detection, or by being switched on. In this way, for example, a temporary quiet zone could be provided in an open-plan office or the like, without the need for providing relatively high-mass walls around the zone, but just by activating the ceiling, floor or adjoining wall panels. Similarly, providing patient privacy, for example in a hospital, could be achieved by activating the smart surface over or under a bed when occupied. This would also have the advantage of providing quieter conditions for a patient without the need for a separate room.

Where an intermittent reactive smart surface is required, for example window or double glazing unit that detects and reduces for example aircraft noise, or building site noise transmission into a building, it will be preferable to integrate the sensor into the actuator and mount the actuator onto the outer glass panel to facilitate more accurate sensing.

Increasing demand on the part of building regulators has also increased the requirement to provide sound insulation both from out-with and within temporary buildings. The current construction methods used are limited in the amount of noise that they can insulate against resulting in these types of buildings not being suitable for human habitation unless more material (and weight and cost) is added. The integration of an active smart surface sound screen to the external panel walls of these buildings would allow the manufacturer to comply with these new regulations without increasing the material content significantly.

Active smart surfaces could be used in trains where external track noise or tunnel noise needs to be reduced or masked.

Where others have claimed the accuracy of positioning of the actuator is critical to the performance of the panel, the massive power output of the magnetostrictive enables the actuator to be discreetly positioned in the corner of the smart surface or any other suitable place that does not affect the users view (if glass) or other functionality that the smart surface might have.

The system that provides the functionality of smart surfaces in its simplest form is a sign generator that provides an audio signal to the device within or on the panel. This will reside within the encoder interface box.

It can be appreciated that more complex systems, including sensing capability functionality can be built into this system which when combined with a digital signal processing system will allow any specific smart surface to be both monitored and addressed. In this way an alarm or a specific noise reducing signal can be sent to the identified smart surface address by the processor. This could include activating external devices such as CCTV cameras or security.

It will be necessary to have a number of inputs and outputs on the encoder interface box. These have been shown schematically in Figure 5.

It is intended that the encoder interface box is completely universal and able to accept inputs from a wide range of devices including analogue and digital audio, microphone and sensors.

Equally it is intended that this device can be used to monitor and affect the output on a multiplicity of devices including as described but not limited to magnetostrictive devices.

If this approach was taken within, say, an office building any window fitted with a two way sensing system could be used as a communicator to any other window similarly fitted as a form of intercom or communication system.

As each device may be fitted with its own signal amplifier, or provided for from the centralised processor, an ability to input at any point in the system could be limited to

audio reproduction either within the bounded volume or a single panel locus, or transmitted throughout the full installation.

This would have the advantage of allowing centralised digital audio to be stored for distribution throughout the smart surfaces in the building or to locally addressed surfaces only.

Brief Description of the Drawings

In the drawings, which illustrate exemplary embodiments of the invention:

Figure 1 is a diagrammatic sectional view of a combined acoustic actuator and sensor;

Figure 2 is a similar view of an alternative configuration of actuator and sensor;

Figure 3 is a diagrammatic sectional view through a double glazed window panel having installed therein a combined actuator and sensor according to yet another embodiment;

Figure 4 is a similar view to that of Figure 3, showing the actuator and sensor device installed in a wall cavity; and

Figure 5 is a block circuit diagram of a controller in accordance with the invention.

Detailed Description of the Illustrated Embodiments

Referring first to Figures 1 and 2, the actuator is essentially as described in our co-pending International Patent Application PCT/GB02/01111, having a housing 1 which serves also as a reaction mass and which contains a core 2 consisting of an element of a giant magnetostrictive material ("GMM") surrounded by an electromagnetic coil and located between permanent magnets. The element is pre-stressed by springs 3 and coupled to a pusher 4 which is in turn connected to a foot 5, which in use is pressed against a surface into which the acoustic wave is to be transmitted. A piezo-electric sensing element 6 is incorporated into the actuator to sense acoustic signals in the surface to which the actuator is attached. In the example shown in Figure 1, the sensing element 6 is provided on the external surface of the foot 5, while in the example shown in Figure 2, the sensing element is located between the core 2 and the internal surface of the housing 1.

Figures 3 and 4 illustrate a different type of combined acoustic actuator and sensing element, in different locations in use. The actuator/sensor device 30 is of the type

described in our application No GB0229954.3 and has the core 31 extending between the main body 32 of the actuator and a foot 33 pivotally mounted thereto with a spring connection holding the components 32 and 33 together and providing a pre-stress to the GMM element within the core 31. In Figure 3, the actuator 30 is mounted between the spaced glass panes 34 and 35 of a sealed double-glazed window unit so as to act on one of the panes. The piezo-electric sensing element 36 is mounted between the foot 33 and the pane 35. In Figure 4, the actuator 30 is mounted on the inner face of a plasterboard wall or ceiling member 41 which can be conventionally mounted on battens 42 attached to a solid wall structure 43. Alternatively, the wall may be a studwork structure or any other building structure involving plasterboard or other boarding. The actuator 30 in Figure 4 may be the same as that in Figure 3, or the piezo-electric sensing element may be incorporated into the actuator, for example between the core 31 and the main body 32.

Figure 5 illustrates a typical configuration of controller for the system of the invention. The controller includes a central processor 50 provided with audio inputs 51 for music, announcements or communications, for example, together with sensor inputs 52 connected to the sensing elements in the actuators coupled to the controller, for example those illustrated in Figures 1 to 4. A mains power supply 53 is included. Battery backup may also be provided. An audio output 54 is provided to a power amplifier 55. This may in turn be connected to a number of actuators in the building or vehicle, for example, or a separate feed and amplifier may be provided to individual actuators or to separate groups of actuators. A white noise generator 56 is connected to the processor to provide a sound-masking output to the actuators or to selected actuators in response to detected noise or to prevent espionage by monitoring vibrations in windows or other panels, for example. A noise recognition module 57 compares acoustic signals detected by the sensors with a library of acoustic signatures to recognise a potentially damaging attack on a panel, for example by cutting or scratching, and outputs an alarm signal in response to detection of such a signal. The alarm signal can give rise to audio output to the panel concerned and/or to adjacent panels, and a message can also be transmitted to a remote monitoring location via a communications interface 58 and communications link 59 (e.g. RS232/RS488/IEEE 488.2/Ethernet).

CLAIMS

1. An audio system, comprising an audio frequency actuator coupled to a panel as to cause the panel to radiate sound when an audio signal is supplied to the actuator by a controller, and an acoustic sensor coupled to said panel or to an adjacent panel so as to sense acoustic vibrations in said panel, the sensor being connected to the controller, whereby the controller is arranged to change the audio signal supplied to the actuator according to the vibrations sensed by the sensor.

2. An audio system, comprising an audio frequency actuator coupled to a panel so as to cause the panel to radiate sound when an audio signal is supplied to the actuator by a controller, and an acoustic sensor coupled to said panel or to an adjacent panel so as to sense acoustic vibrations in said panel, the sensor being connected to the controller, whereby the controller is arranged to detect predetermined characteristics of the sensed acoustic vibrations and to output an alerting signal in response thereto.

3. An audio system according to Claim 1or 2, wherein the actuator and the sensor are coupled to the same panel.

4. An audio system according to Claim 3, wherein the sensor is incorporated into the actuator.

5. An audio system according to any preceding claim, wherein the actuator is a magnetostrictive actuator.

6. An audio system according to any preceding claim, wherein the sensor is a piezoelectric device.

7. An audio system according to any preceding claim, wherein the panel is a ceiling panel, a wall panel, a floor panel or a window pane of a building or vehicle.

8. An audio system according to any preceding claim, wherein the controller is arranged to detect acoustic signals with predetermined characteristics in the output from the sensor and to supply to the actuator an audio output signal selected according to said characteristics.

9. An audio system according to Claim 8, wherein the detected characteristics represent ambient noise and the output signal is a random sound signal such as white noise or pink noise adapted to provide a degree of masking of the ambient noise.

10. An audio system according to Claim 8, wherein the detected characteristics represent the quality of the audio signal supplied to the actuator and the controller is adapted to correct the supplied audio signal in accordance with the detected characteristics to improve the sound radiated in the space.

11. An audio system according to Claim 2, wherein the predetermined characteristics represent a damaging attack on said panel.

12. An audio system according to Claim 2, wherein the predetermined characteristics represent the sounds generated by a person within the space.

13. An audio system according to Claim 2, 11 or 12, wherein the alerting signal causes output of an audible and/or visible alarm.

14. An audio system according to Claim 12, wherein the alerting signal is used to control the operation of lighting and/or heating within the space.

15. An audio system according to Claim 12, wherein the alerting signal is used to control the supply of audio signals to the actuator.

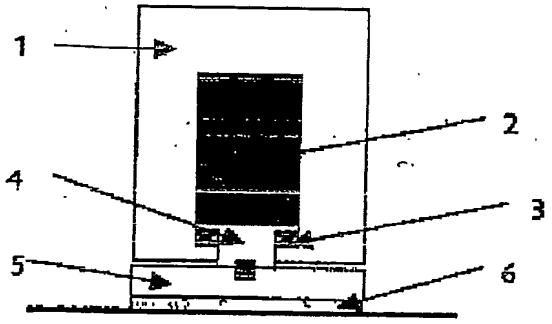

Fig 1

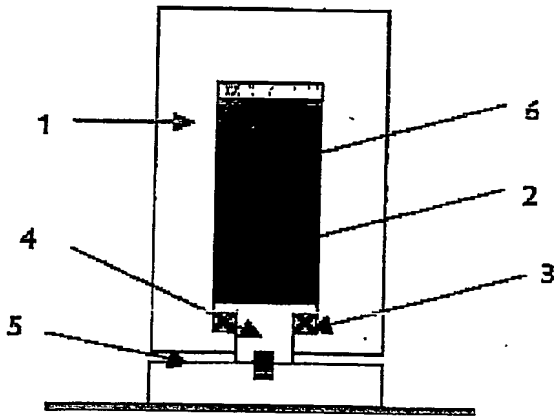

Fig 2

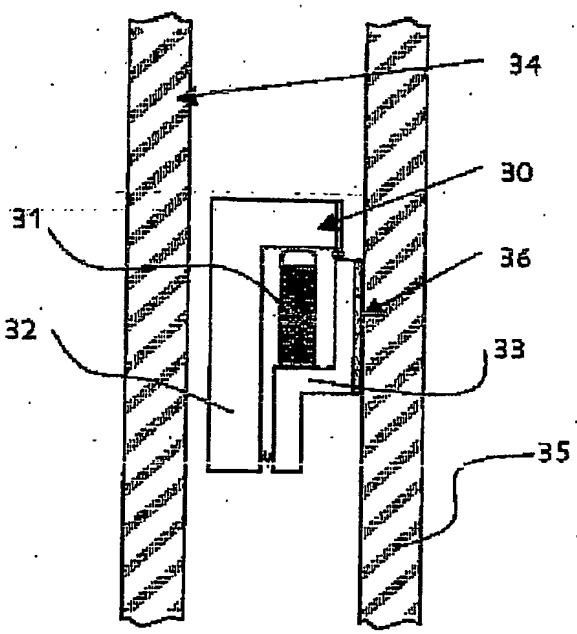

Fig 3

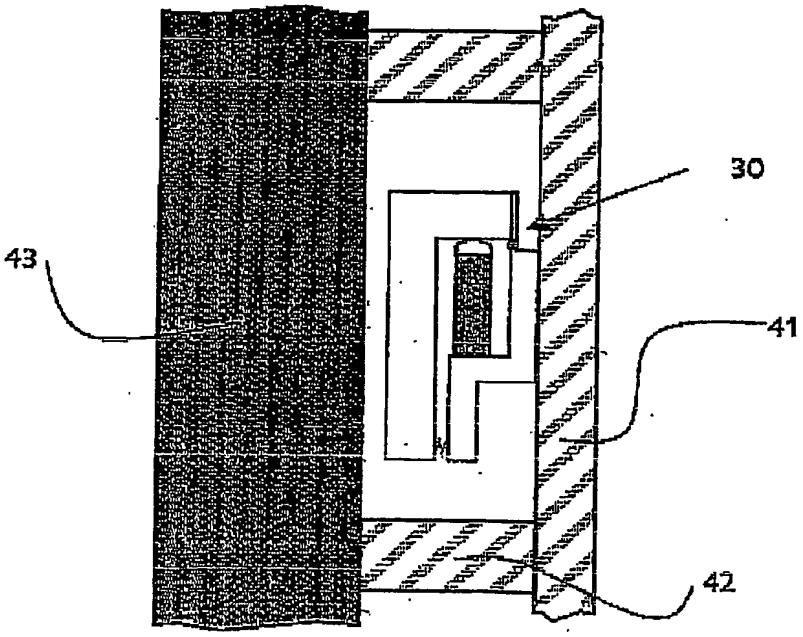

Fig 4

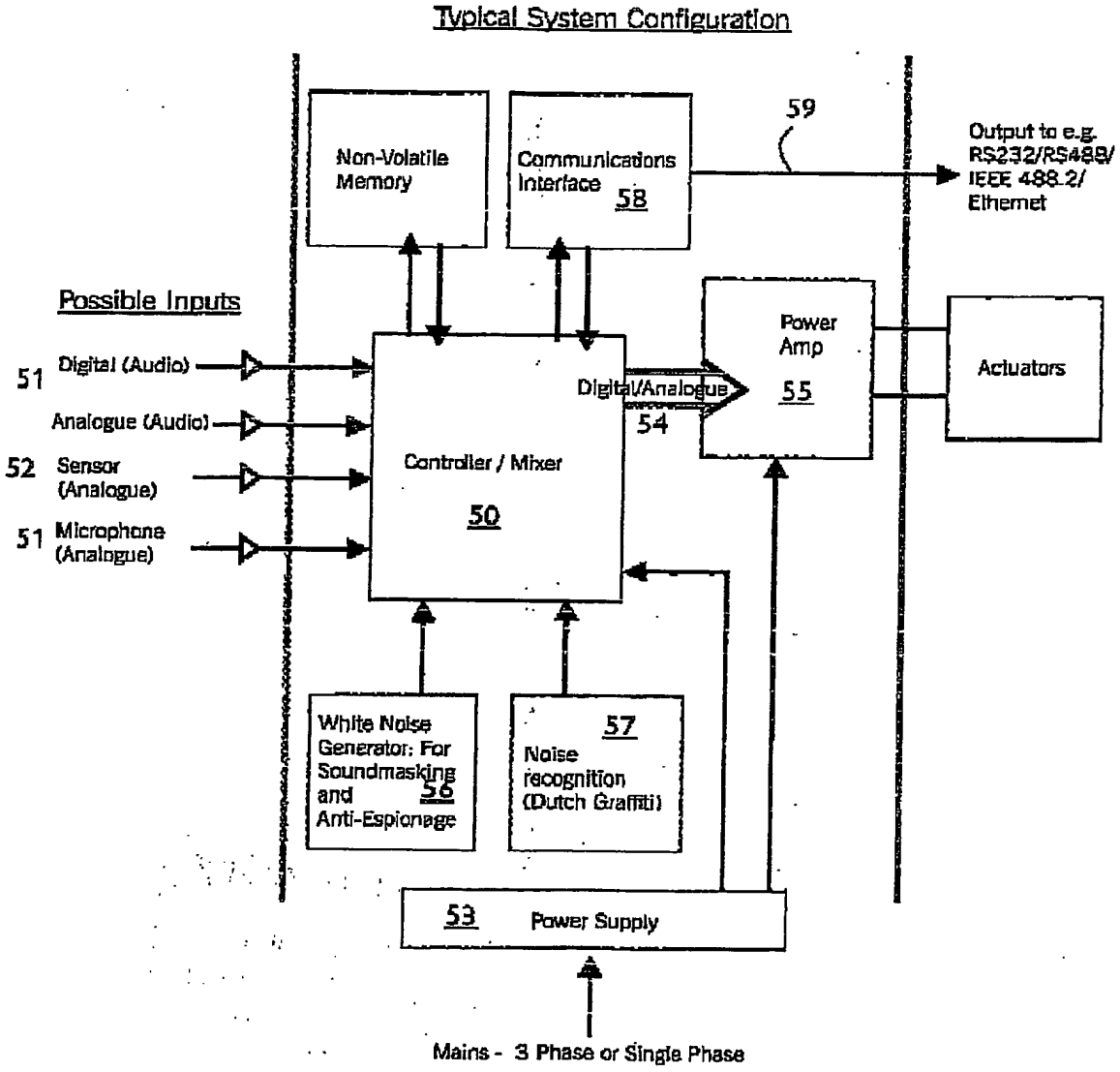
Typical System Configuration
Non-Volatile Memory
Communications Interface 58
59
Output to e.g. RS232/RS485/ IEEE 488.2/ Ethernet
Possible Inputs
51 Digital (Audio)
Analogue (Audio)
52 Sensor (Analogue)
51 Microphone (Analogue)
Controller / Mixer 50
Digital/Analogue 54
Power Amp 55
Actuators
White Noise Generator: For Soundmasking and Anti-Espionage 56
57 Noise recognition (Dutch Graffiti)
53 Power Supply
Mains - 3 Phase or Single Phase

Fig 5

PCT/GB2004/002361